



Double Trouble



5 Lessons for taking action against invasive species (AIS) and climate change threats to the Great Lakes Ecosystem

These lessons introduce students to invasive species and their effects on ecosystems by examining local examples in the Great Lakes Freshwater Ecosystem. It explores what makes a species invasive, problems associated with invasive species, how invasive species impact food webs, how climate is related to latitude and species location, how climate change could affect species movement and population, and possible solutions to the problems.

Students will research the interdependencies among plants and animals in an ecosystem and explore the role climate plays in their survival. They will compare ecosystems from different parts of the world by learning more about invasive species in their own back yard and also about their place of origin. They will use these comparisons to determine if a species could survive in a new ecosystem and form hypotheses on the effects climate change might have on their movement and survival. Finally they will share what they learned with their classmates and the community.

Material from the Union of Concerned Scientists Curriculum Guide: <http://www.climatehotmap.org/> and Michigan Sea Grant Project Flow: <http://www.miseagrant.umich.edu/lessons/> was used to create these lessons with revisions and additions compiled by Pennsylvania Sea Grant.

Duration: Five 50 min class periods. Some of the activities can be assigned as homework.

Key terms: Invasive (exotic) species, ecosystem, habitat, GIS, GPS, latitude, longitude, altitude, population, spatial, biodiversity, climate change, climate vs. weather, Meteorologists, Climatologists

Objectives:

- Learn what makes a species invasive and find examples in the local environment.
- Choose an invasive species and research its native ecosystem to determine habitat preferences, including the climate of that region.

- Determine latitude, longitude, altitude, and climate to understand the distribution of species and compare how regions differ.
- Determine the potential effects climate has on movement and populations of invasive species.
- Use food webs to demonstrate differences between place of origin and invaded region.
- Form a hypothesis that explains the possible effects climate change will have on species and what the ecosystem might look like in 2100.
- Suggest solutions for managing ecosystems and minimizing AIS/climate change impacts, including what students can do.

Assessment: Students will be assessed on participation in class discussions, their answers to questions included with these lessons, food web illustrations, their hypothesis on the effect climate change will have on invasive species, a written report, and a letter to the editor.

The report will cover an invasive species of the student's choice, its place of origin, including latitude, longitude, altitude, climate, and preferred habitat. Each student will prepare a description of the native ecosystem using a web for illustration. They will also use a web to show the connections in a Great Lakes area near their home that their species has invaded. Students will use their research on AIS and climate to predict how climate might impact species movement and survival in new locations. They will form a hypothesis that includes a description of what they think their ecosystem might look like in 2100 if projected climate changes occur, using a new web for illustration. Students will also write a letter to the editor that can be submitted to the local newspaper or school newspaper explaining the double threat of AIS and climate change and ways readers can make a difference.

National Science Education Standards

Unifying Concepts and Processes (K-12):

Consistency, change, and measure

Science as Inquiry, Content Standard A (9-12): Abilities necessary to do scientific inquiry; Understandings about scientific inquiry

Life Science, Content Standard C (9-12): Interdependence of organisms; Matter, energy, and organization in living systems; Behavior of organisms

Earth and Space Science, Content Standard D (9-12): Energy in the Earth system

Science in Personal and Social Perspectives, Content Standard F (9-12): Environmental quality; Science and technology in local, national, and global changes

Social Studies

Strand 3: People, Places, and Environments

Strand 8: Science, Technology, and Society

Strand 9: Global Connections

Geography

Standard 4: Places and Regions. The physical and human characteristics of places.

Standard 8: Physical Systems. The characteristic and spatial distribution of ecosystems on the Earth.

Technology

Standard 1: Basic Operations and Concepts. Students are proficient in the use of technology.

Standard 5: Technology Research Tools. Students use technology to locate, evaluate, and collect information from a variety of sources.

Environmental Education

Strand 1: Questioning and Analysis Skills

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

Strand 2.2: The Living Environment

Strand 2.3: Environment and Society

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.3: Skills for Analyzing and Investigating Environmental Issues

Strand 3.4: Decision-making and Citizenship Skills

Language Arts

Standard 4: Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 8: Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create/communicate knowledge.

Standard 12: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information.)

Materials and Preparation

- A student worksheet to guide your students' research and participation in these lessons.
- A world map with lines of latitude and longitude
- A world map that shows latitude and climate zones
- GLERL, Michigan Sea Grant FLOW lessons and PA Sea Grant/Erie Times-News publications on food webs, invasive species and climate change
- Union of Concerned Scientists Climate Change in the Great Lakes Region Technical Appendix .pdfs
 - Impacts of Higher Lake Temperatures and Fish Responses To Climate Change
- Invasive species and climate change a 'deadly duo' | MNN - Mother Nature Network pdf
- Computers with internet access for researching chosen invasive species to find maps, place of origin, location of invasions, climate, altitude, etc.
- How to write an effective letter to the editor pdf

Prerequisite Knowledge - Teacher

The geographic ranges of plant and animal species are affected by climatic factors such as temperature, precipitation, soil moisture, humidity, and wind. A shift in the magnitude or variability of these factors in a given location due to global climate change will likely impact the organisms living there.

It is very important to understand the difference between climate and weather. Although weather and climate are related, they are not the same. “What you get is weather, while what you expect is climate.” Our current weather may be record cold or hot, but it is not our climate.

Meteorologists describe the atmospheric conditions at a particular time and place, such as temperature, rainfall, wind, and humidity. Weather includes cold fronts or warm fronts, record cold, snow, sunshine, rain, cloud cover, winds, hail, sleet, freezing rain, flooding, blizzards, ice storms, thunderstorms, steady rains, excessive heat, heat waves and more. Because the atmosphere behaves like a fluid, these conditions can change rapidly, making weather especially difficult to predict more than one week in advance.

Climatologists don't try to predict short-term weather at any single location. They consider average patterns of weather for a particular region over long periods of time. The National Weather Service uses weather data to determine climate by taking the averages of recorded precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, hail storms, and other measures of the weather. For example, by using the sum of these weather records, lake and reservoir levels, and satellite data, climate scientists can tell if an area was drier or warmer than average during a summer. If it continues to be drier and warmer than normal over the course of many summers, then it would likely indicate a change in the climate. The majority of scientists agree that if nothing is done to curb greenhouse gases, climate change will have potential devastating effects on the wildlife and people that inhabit this planet.

Global climate change may also make conditions more suitable for invasive species.

- Species sensitive to temperature may respond to a warmer climate by moving to cooler locations at higher latitudes or elevations.
- Factors other than climate may limit the extent to which organisms can shift their ranges. Physical barriers such as mountain ranges or extensive human settlement may prevent some species from shifting to more suitable habitats. In the case of isolated mountaintop species, there may be no new habitat at higher elevation to colonize.
- Even in cases where no barriers are present, other limiting factors, such as nutrient or food availability, soil type, and the presence of adequate breeding sites, may prevent a range shift. See the EPA's global warming Web site for a discussion of factors that could limit a range shift for species at <http://www.epa.gov/climatechange/impacts-adaptation/>.

- In addition to the direct effects of temperature on organism physiology, projected climate changes under an enhanced greenhouse effect might change the availability of food, space, shelter, or water; upset the predator/prey balance of an ecosystem; increase susceptibility to pests/disease; and change the frequency of natural hazards such as fires, droughts, and flooding. These effects might lead to local population declines or extinction for some species.

Latitude and Longitude explained

The planet's four hemispheres are each shaded a dark gray.

The **Equator**, that imaginary horizontal line at 0° degrees latitude at the center of the earth, divides the earth into the Northern and Southern Hemispheres.

The vertical imaginary line called the **Prime Meridian**, at 0° degrees longitude, and its twin line of longitude, opposite the Prime Meridian at 180 ° longitude, divides the earth into the Eastern and Western Hemispheres.

Therefore (*with some exceptions*) all countries north of the Equator are in the Northern Hemisphere, while all countries south of the Equator are in the Southern Hemisphere. In addition, all countries west of the Prime Meridian are in the Western Hemisphere while those east of the Prime Meridian are in the Eastern Hemisphere.

Generally the **Eastern Hemisphere includes** most of Africa, about half of Antarctica, all of Asia and Australia/Oceania, and most of Europe.

The **Western Hemisphere includes** about half of Antarctica and all of North and South America, which includes the Caribbean and Central America as well as Greenland.

The **Northern Hemisphere includes** all of North America, the northern reaches of South America, about two-thirds of Africa, all of Asia excluding (*parts of Indonesia*) and all of Europe.

The **Southern Hemisphere includes** most of South America, one-third of Africa, all of Antarctica, a small sliver of Asia (*parts of Indonesia*) and all of Australia/Oceania.

There are exceptions as some continents (*and their countries*) based on the straight-line divisions of the Equator and Prime Meridian are a part of two hemispheres. For a map and list of countries in both the Eastern and Western Hemispheres, go [here](#), and for countries in both the Northern and Southern Hemispheres, try this [page](#).

Prerequisite Knowledge - Student

Students should understand the concept of an ecosystem, including the relationship between abiotic and biotic factors and how a food web works. Excellent lessons include Project Flow from Michigan Sea Grant Unit 1 - Food Web (included with the resources)

Students should know the physical/atmospheric measurements that are used to characterize a region's climate and understand the difference between climate and weather - (have them read the PA Sea Grant/ Erie Times-News published page "Our weather isn't the same as long-term climate.")

Lesson 1: Identifying the invaders and what makes a species invasive

Invasive species are not native to an area and have no natural predators, resulting in overpopulation. Exotic species are not generally considered to be invasive until they begin to cause ecological or economic harm, or harm to human or animal health. Invasive species are typically introduced to an area by humans, historically through colonization, and presently as a result of increasing travel and trade. For example, European colonists brought horses, cattle, and seeds, like those to plant grapes, to use in the new world. Unfortunately, their ships also brought unintentional species like black rats and European house mice. With each ecosystem having special interconnected relationships that have developed through millions of years, introducing a new species to that web of relationships often has unintended consequences, including extinction for some species. In fact, since early colonization, over 500 native North American species have gone extinct, and in a recent inventory of 20,000 native species by the Nature Conservancy and the National Heritage Network, one-third were found to be at risk of extinction.

There are many foreign species that have "taken over" in North America, including house sparrows, domestic pigeons, European starlings, English Ivy and the Kudzu plant. Kudzu, native to Japan, was first introduced in the U.S. south as an ornamental plant and to reduce soil erosion. The plant flourished in the humid weather, and, without natural predators to check its growth, quickly spread all over the south region. The kudzu vine can grow up to sixty feet in a year, and now dominates the southern U.S. in residential neighborhoods and forests. They crowd out native species, and smother trees and houses.³ Growing 4,600 acres a day⁴, this plant costs \$500 million each year in control costs and lost cropland.

Affecting many parts of the world are the following invasive species: Africanized honeybees, brown tree snakes, cane toads, Asian long horned beetle, Asian tiger mosquito, Dutch elm disease, water hyacinths, yellow crazy ants, and zebra mussels. Lead a discussion on the characteristics of an invasive species and why they can be so harmful to the ecosystem. Some points to include in your discussion are:

- What makes a species invasive?
- How do invasive species come to be in an area?
- How can the addition of an unnatural species impact an ecosystem?
- What ways can you suggest to help control invasive species? Consider both preventative measures and methods of removal.

Step 1: Have students research invasive species in your region. If you live in the Great Lake region, a good place to start is by using the .pdf resources from PA Sea

Grant and GLERL provided with these lessons. Another good place to start is www.invasivespeciesinfo.gov. The sidebar on the left allows you to search for information by geography. If there is limited information in your area you may also research invasive species by region, i.e. Southeast, Western United States, etc.

Step 2: Have each student choose a local invasive species to research. Research should include where the species originated, where it has spread, how it was introduced, and what effects it has on other wildlife, humans, and the economy (money it takes to manage the invasive species or loss of income caused by the invaders).

Lessons 2, 3, 4 and 5: Determining whether a selected species will succeed in invading a new ecosystem by comparing ecosystem locations and climate

This lesson provides students with meaningful opportunities to determine latitude, longitude, altitude, and climate differences in the world by exploring the movement of invasive species.

An ecosystem is defined by its geography, climate, soil, water resources, and species. In ecology, a biome is a major regional group of distinctive plant and animal communities best adapted to the region's physical natural environment, latitude, altitude and terrain.

A map of the world's freshwater ecosystems, as identified by the World Wildlife Fund, can be found here <http://www.feow.org/>. You can look up your own area, print out the map and discuss your ecosystem with the students.

Have students research their selected invasive species and record the geography, climate, soil, and water resources of its place of origin. Have students include latitude, longitude, altitude, climate, and other ecosystem characteristics. They will fill in the chart on their worksheet with this information so they can compare locations to determine if a species will succeed in their local environment. They will also use it to decide what effects climate change might have on AIS movement to new environments.

Forming hypotheses about climate change

Have the students re-evaluate the species they researched from a climate change perspective. If students are not already aware of potential climate change impacts ask them to explore this by visiting: <http://www.climate.org>. Have them read PA Sea Grant/Erie Times-News published pages "Double trouble - Climate Change might hasten spread of AIS" and Empty nesters - Climate Change threatens birds feeding", and the news article: "Invasive species and climate change a 'deadly duo' ".pdf from|MNN - Mother Nature Network. They can also use the Union of Concerned Scientists "Climate Change in the Great Lakes Region Technical Appendix" .pdfs

- Impacts of Higher Lake Temperatures
- Fish Responses To Climate Change

Once the students have a firm understanding of local impacts of climate change, have them evaluate how these changes may or may not interact with the ecosystems of the invasive species. Students should hypothesize impacts of rising temperature, more/less frequent precipitation, and an increase in extreme weather events such as drought and flooding on their chosen invasive species. Their hypotheses should also include whether the species' spread would be impacted by climate change and how.

Procedure

Part 1: Class discussion on vegetation and animal species

Using their prior knowledge only, ask students to answer these questions:

- In what ways does climate affect plants and animals?
- How does latitude and altitude determine what types of species live in a region?
Have students look at a world map of vegetation and evaluate how climate influences the distribution of plants.
- Identify the ways in which temperature affects the life cycle of animals (e.g., migration, hibernation, and breeding).

Develop a list of climatic effects on plants and animals from student answers that can be used as a reference guide for student research.

Ask students to research, as a class, the basic components of a freshwater ecosystem. Students should look for organisms in each category of producers, herbivores, omnivores, carnivores, and decomposers. Nature guides, library books, and the Internet could all be sources of information for this exercise. The web sites of State Departments of Conservation or the local Audubon Society would be good resources. If possible, take students on a field trip to collect data on the types of plants and animals found in the ecosystem.

Have students complete the species observation questions on their report form to focus their research. They can use guidebooks like Pennsylvania Sea Grant's publication "Pennsylvania's Field Guide for Aquatic Invasive Species" to assist with information for their reports and identifications in the field if you are able to take them on a field trip. Supplement the field observations with Internet or library research. A good online field guide can be found at eNature.com – see Suggested Resources.

After the class has finished their research, have each student create a web (using drawings or pictures, for example) of the basic components of the ecosystem showing interrelationships. (See Michigan Sea Grant Project FLOW Unit 1 Food Webs.) The web should include physical factors such as the sun, atmosphere, water, soil, and nutrients. At this point, students can begin to develop hypotheses concerning how climate change might affect the ecosystem. Ask each student to read the text on "Plant and Animal Range Shifts" from the *Global Warming: Early Warning Signs* map to learn how climate change affects organisms. Then have each student prepare a report to be presented orally to the class on how climate change could affect their chosen invasive plant or animal in the regional ecosystem.

Students can also use the information generated by the class in the Part 1 activity above.

Teachers should use the regional reports of the U.S. National Assessment at <http://www.usgcrp.gov/usgcrp/nacc/default.htm> to find the projected climate changes for their region of the country. The table of climate changes in the example “Guidelines for Students” can then be modified to fit the regional projections.

Each student should present his/her research findings in the form of a hypothesis concerning how the projected climate changes might affect their organism, and the reasoning behind the hypothesis.

Explain that each student will be expected to write a summary essay reflecting how the ecosystem as a whole might be different if the projected climate changes occur. It should include a description of the ecosystem as it is today using a web for illustration. Finally it should include a description and web illustration of what they think the ecosystem might look like in 2100 if the projected climate change occurs. This makes each student responsible for understanding the material presented by other members of the class.

Extended Procedure

1. Ask students to make a list of the measurements that could be taken to try to detect the beginning signs of climate change in the ecosystem. Ask them to consider physical, biological, and chemical measurement possibilities. This exercise could be done as a class activity, or it could be included in the writing assignment in #5 from above.
2. Have students research the possible effects of climate change on an ecosystem that is significantly different from the one they have just studied. Depending on your school location, this might be a coastal system, coral reef, desert, or mountainous area. If possible, pick an area in a country other than the United States (e.g., Great Barrier Reef, Canadian Arctic). The **World Wildlife Fund** web site is a good source for information on climate change impacts in internationally protected areas. Ask students to compare and contrast the impacts in each of the two systems they have studied.

Other Suggested Resources

- NOAA Climate Services (National Oceanic and Atmospheric Administration) <http://www.climate.gov/#climateWatch>
- A good starting point for student research on climate change impacts on ecosystems is <http://www.epa.gov/climatechange/impacts-adaptation/>. Reports are available by ecosystem type (coastal zone, forests, wetlands, etc.), by animal type (birds, fisheries), and by state.

- For in-depth research, this site offers an extensive listing of scientific articles about the impacts of climate change on wildlife. World Wildlife Fund Climate Change Campaign http://www.panda.org/about_wwf/what_we_do/climate_change/solutions/where_we_work/index.cfm. This site is an overview of WWF's goals for reducing climate change and a gateway to online reports on the WWF projects against climate change worldwide, as well as key effects and potential solutions of climate change in each world region.
- eNature Online Field Guides <http://www.enature.com>
A user-friendly site where students can see pictures and read about plant and animal species found in different habitats of North America (scroll down to the "Habitat Guides" section). Teachers can also create a classroom species list.
- Global Climate Change Online Resources <http://www.aaas.org/climate/>
A comprehensive listing of online resources about global climate change, arranged by topics such as events, recent news, the science, and what you can do.
- The Intergovernmental Panel on Climate Change (IPCC) - Approximately every five years, IPCC releases an assessment of the state of climate change science. The latest assessment, Climate Change 2007, is available online in four parts. Each part includes an executive summary.
- The Physical Science Basis section: <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>
- The Impacts, Adaptation, and Vulnerability section (outline form): [link unavailable]
- The Mitigation of Climate Change section (pre-copy-edit version): http://www.mnp.nl/ipcc/pages_mediaAR4-chapters.html
- Union of Concerned Scientists (UCS). The UCS Web site contains many resources for teaching climate change. Below are links to several of these.
 - Confronting Climate Change in the Gulf Coast Region <http://www.ucsusa.org/gulf/>
 - Confronting Climate Change in California http://www.ucsusa.org/global_warming/science/confrontingclimate-change-incalifornia.html
 - The Science of Climate Change http://www.ucsusa.org/global_warming/science/

Global Warming: Frequently Asked Questions

http://www.ucsusa.org/global_warming/science/global-warming-faq.html

- Common Sense on Climate Change: Practical Solutions to Global Warming

http://www.ucsusa.org/assets/documents/global_warming/climatesolutions.pdf

Double trouble - Student Report

Name _____ Date _____

NOAA (National Oceanic and Atmospheric Administration) Climate Services (<http://www.climate.gov/#climateWatch>) has asked your class to evaluate the dual threat of aquatic invasive species (AIS) and climate change on the Great Lakes freshwater ecosystems in your state. For decades, NOAA, and the National Sea Grant Program administered by NOAA have provided essential information about our climate, invasive species and other information that anticipates future risks, saves lives, protects property and safeguards the economy.

Your class will work together to identify species that are considered invasive in the Great Lakes. To understand how species become invasive you must learn more about the ecosystem where they originated and more about the Great Lakes and other ecosystems that may be threatened by their presence.

Because the organisms in any ecosystem function in a complex web of interdependencies, your class will also need more information to evaluate the role climate plays in determining if a species will become invasive in a new region and how climate change would affect the system as a whole.

Your assignment as a member of the NOAA dual threat evaluation team is to form a hypothesis that describes in detail how the projected climate changes could impact species movement and their potential for invading new regions.

You will present your findings to the class and use this information, and that of your teammates, to construct “before” and “after” pictures of the ecosystem, using both text and illustrations. In your research, try to consider all of the ways in which climate could impact your species, both directly and indirectly.

The questions below will help you get started, but you may be able to identify other important relationships between your species and climate. Be creative!

The following questions will guide your research and your answers will be used for a portion of your grade.

1. Together with your classmates compose a list of species that are currently considered invasive in the Great Lakes ecosystem. (PA Sea Grant/Erie Times News publications provided by your teacher about invasive species and <http://www.glerl.noaa.gov/res/Programs/ais/> can help you)

Choose one of the species listed above for your report.

My invasive species is:

When and how did your invasive species get introduced to the Great Lakes?

Is your species harmful to the local environment? If so, how?

Before researching your species you need to brush up on latitude, altitude and climate because these play an important role in determining whether a species can survive in a new location.

Activity 1: Finding latitude and altitude

For practice pinpoint the latitude and longitude of your school on the map provided by your teacher. Then use your school's street address to search Google Maps to find the altitude and to check your answers.

Answer the following questions about location:

Is your school north or south of the Equator? _____

Which two lines of latitude is your school between? _____

Find the midpoint by splitting the difference between the two lines. Is the school closer to the midpoint or one of the lines? Estimate the degrees latitude. _____

Is your school east or west of the Prime Meridian? _____

Which two lines of longitude is your school between?

Determine the midpoint by splitting the difference between the two lines. Is the school closer to the midpoint or one of the lines? Estimate the degrees longitude.

Is your school high in the mountains or at sea level or somewhere in between? What is the altitude of your school's location? _____

You can find the altitude of a location by typing the location or address in <http://www.daftlogic.com/sandbox-google-maps-find-altitude.htm>. You can also check latitude and longitude on Google Maps.

- Write the latitude, longitude and altitude of your school in the chart.

Determine latitude, longitude and altitude for the place your native species originated and also for the Great Lakes location in your area where it has become invasive and record them in the chart below.

You will also need to determine if your species could become invasive in Great Bear Lake in the Northwest Territories, Canada or Death Valley in the Mojave Desert, so record the latitude, longitude and altitude for these locations and record them in the chart.

Location Name	Latitude(N/S)	Longitude (E/W)	Altitude
Your school			
Origin of chosen species:			
Great Lakes location:			
Death Valley, Mojave Desert			
Great Bear Lake Northwest Territories, Canada			

Compare these values and list the locations in order of their distance from the equator with the one closest to the equator first.

1. _____
2. _____
3. _____
4. _____
5. _____

Activity 2: Climate

Do you know why one area of the world is a desert, another a grassland, and another a rainforest? Why are there different forests and deserts, and why are there different types of life in each area?

The answer is climate. **(It is important not to confuse climate with weather. Remember: “Weather is what you get, climate is what you expect.”)**

Climate is the characteristic condition of the atmosphere near the earth's surface at a certain place on earth. It is the **long-term** weather of that area (**at least 30 years**). This includes the **region's general pattern of weather conditions, seasons and weather extremes** like hurricanes, droughts, or rainy periods. (Read PA Sea Grant/Erie Times News publication Weather vs. climate for more information.)

Because the climate of a region will determine which plants and animals will survive and thrive, it is important that you record the climate for each of your locations in the chart below. It will help you determine which species might become invasive in a new location.

Location Name	Climate
Your school	
Origin of chosen species:	
Great Lakes location:	
Death Valley, Mojave Desert	
Great Bear Lake Northwest Territories, Canada	

Predict the areas above where your species could survive and might become invasive based on the climate. Explain your answers.

Activity 3: Your species and climate

To determine how climate change might affect a particular species, scientists must first try to understand all of the ways in which present climate influences that species.

Research the life cycle, habits, and physiological needs of your species to identify the ways in which climate affects it today. For many species, the climate where they live or spend part of the year influences key stages of their annual life cycle, such as migration, blooming, and mating. The geographic ranges of plant and animal species are also affected by climatic factors such as temperature, precipitation, soil moisture, humidity, and wind.

Use information about your species to answer the questions below: (The Pennsylvania Sea Grant Field Guide of Invasive Species is one helpful resource. You can also use the internet resources provided by your teacher.)

Life Cycle:

What are the life stages of the species?

When do changes from one stage to another take place?

How is the species affected by the seasons?

How does the species reproduce? When and how often does it breed?

Food:

What are the nutritional needs of the species?

What are its preferred foods?

What are other food sources?

What do the young eat?

Is the food supply influenced by the seasons? _____

Its place in the food chain is (circle one): producer, herbivore, carnivore, omnivore, decomposer.

Shelter:

Where does the species live in the ecosystem?

Does it share this space with other species?

What kind of shelter does it need for breeding/raising its young? _____

Predators/Disease:

What species, if any, depend on this species for food (or parasitic/symbiotic relationships)?

What diseases or pests affect this species?

What conditions make the species susceptible to disease? _____

Competitors/Predators

What species compete with this species for food, shelter, or other needs?

What, if anything, maintains a balance among these competitors? _____

Does your species have any natural predators in its native location?

Describe the ecosystem of the origin of your chosen species. (An ecosystem is defined by its geography, climate, soil and water resources, and species. A map of the world’s freshwater ecosystems, as identified by the World Wildlife Fund, can be found at [http://www.feow.org/.](http://www.feow.org/))

Illustrate

the function of this species in its **native** ecosystem by sketching interrelationships with other organisms: For examples of Food Webs see Food Web of Lake Erie pdf or go to: http://www.glerl.noaa.gov/res/projects/food_web/food_web.html to find the food webs of all the Great Lakes. Your teacher also has other resources on food webs. Then illustrate its function in the area it has invaded with a new food web. What are the similarities and differences between the two food webs?

Activity 4: Evaluating Climate Change Impacts

Now that you have learned more about geography, climate and your species’ life habits and needs, it’s time to consider how global climate change might play a role in its future. Major regional groups of distinctive plant and animal communities are best adapted to the region's physical natural environment, latitude, altitude and terrain. Climate can affect a species directly by constraining organisms to areas within their temperature tolerances, or indirectly by affecting food supply, availability of shelter, or other factors necessary for survival.

Some scientific studies have suggested that climate change could alter the distribution of species in an area because a warmer climate would cause some species to shift their geographic ranges to cooler areas, either to higher latitudes or to higher altitudes on mountain slopes. Other studies indicate that in areas where species are unable to move to accommodate changing climate conditions, for example, in places where their movement is blocked by large cities, population numbers could decline or local populations could become extinct.

In fact, the impact of climate change on a species is likely to be complex because its survival is linked to many factors. Use the “Union of Concerned Scientists Climate Change in the Great Lakes Region Technical Appendix - Impacts of Higher Lake Temperatures, and Fish Responses to Climate Change” to predict how each of these changes might impact the species you studied.

Characterize the impact as “little or no impact,” “moderate impact,” or “significant impact and describe why.

In addition to the direct effects of temperature on organism physiology, projected climate changes under an enhanced greenhouse effect might change the availability of food, space, shelter, or water; upset the predator/prey balance of an ecosystem; increase susceptibility to pests/disease; change the frequency of natural hazards such as fires, droughts, and flooding. These effects might lead to local population declines or extinction for some species and invasive species will only make matters worse.

Finally form a hypothesis of how climate change will impact your invasive species. In your hypothesis include answers to the following: How will the species be affected by local climate change? Will the effects be adverse or beneficial for this species? Will it continue to spread or will its population decline? If possible will it leave for a climate zone more suited to its needs? What will happen to the native species that make up your local freshwater ecosystem?

Activity 5 - Convincing others to take action

Newspaper Activity: Sciences, Social Studies, Language Arts **Grades 4–12**

Write a letter to the newspaper or to a politician that reflects your learning. Articulate your views and concerns about AIS and climate change by sharing your voice on this dual threat and particularly how it impacts your community.

Topic: Convince readers that they must take action to prevent problems caused by the dual threat of climate change and aquatic invasive species

1. Use what you learned so you can educate others and encourage them to take action. Use facts to support your argument that climate change and AIS are serious problems that must be addressed. Can you convince readers to stop producing excess CO2 and other greenhouse gases and be more mindful of how they can help stop the spread of AIS?
2. Send your thoughts to the editor of your local newspaper or your school newspaper. See key points for writing powerful letters below.

Key Points for Writing Powerful Letters

When writing a letter to the editor

Look for well-written letters from the editorial page. Critique the letters and choose those that do the best job of making their thoughts clear while including supporting facts and evidence. Use them as a guideline for composing your letter. Be sure to:

- Keep the letter short (maximum 250-300 words).
- Have one major message.
- Use a straightforward, factual approach.
- Back up your opinions with evidence.
- Put the main point at the beginning before progressively less important details.
- Ensure the letter is concise, grammatically correct, and has no spelling mistakes.
- Have someone edit the letter – everyone who reads the newspaper will see this letter so make sure it is free of mistakes, clear and easy to understand.
- Include a return address with your name, teacher, and the school's address.

When writing a letter to a politician:

Keep your tone polite.

Keep the letter short - approximately one page typed or two pages of large handwriting.

State your case clearly.

If you or the class is aware of anything positive that the politician has done in regard to climate change or AIS, state it.

If you are planning to criticize, start with a couple of positive comments first.

Express your concerns and support them with facts and comments from scientists and others in your community.

This lesson is one of 10 lessons that focus on climate change and invasive species prepared by the Pennsylvania and New York Sea Grant programs as part of a larger Great Lakes Sea Grant Network initiative funded by the Great Lakes Restoration Initiative.

